such as washing are effective means of reducing exposure to biological agents. Biological hazards may also include rodents, reptiles, insects, and arachnids.

11.2 HEALTH PHYSICS

Health Physics organizations are responsible for administering a radiation safety program that promotes the use of radiation and radioactive materials in a manner that protects workers, the public, and the environment. The uses of a Health Physics program cover a wide spectrum of activities across not only the DOE complex, but other areas as well. Humans are subjected to radiation every day because of natural radioactivity in the environment. Radiation is found in air, earth, water, foods, materials used to build homes, and even in the human body. Radiation and radioactive materials also are used in many ways that benefit humankind, including many diagnostic and therapeutic medical procedures, electricity production, in fire detectors, and food preservation, to name just a few. However, radioactive waste products are generated as a result of these beneficial uses of radioactive materials. These waste products can be in the form of solids, liquids, and gases, and disposing of them efficiently and effectively represents a great challenge.

This section is concerned with those radioactive waste materials contained in the process air streams that potentially could be released to the environment, the local work areas where workers could be exposed to radiation, and radiologically safe removal and replacement of the High Efficiency Particulate Air (HEPA) filter used to minimize potential releases and worker exposures. [This type of filter is usually supplemented by other filters such as the roughing filters that form part of the basic engineering design features of the air handling systems of a facility.]

Radiation safety is the responsibility of both the Health Physics program and the individuals on site. The steps and actions required to maintain occupational exposures at levels that are as low as reasonably achievable (ALARA) are described below. It is incumbent upon each individual working in a controlled area to understand these basic requirements and ensure they are considered when performing work that can result in exposure to radiation. For example, each individual must know and understand the meanings of radiological postings, the radiation levels in the areas where they work, the training required to work in the area, and the importance of following procedures and abiding by the instructions in the procedures and in the Radiological Work Permit (RWP).

11.2.1 HEALTH PHYSICS CONSIDERATIONS FOR HEPA FILTER REMOVAL AND REPLACEMENT

DOE has regulations (10 CFR 835[1]) that require doses to workers and the public to be as low as possible. In addition to DOE regulations, U.S. Environmental Protection Agency promulgated in 40 CFR Part 61 also limit exposure of the public via the air pathway from DOE facilities. DOE policy on radiological health and safety is provided in DOE Policy 441.1[2] with further requirements for worker protection given in DOE Order 440.1A[3]. In addition, there are standards and guidance documents[4-11] that aid in interpretation and implementation of the regulations in 10 CFR 835,[1] from which much of the information in this section is derived. Some background material and some of the basic elements involved in radiation safety programs are discussed in the following sections. Although these elements are applicable to most tasks involving radiation and/or radioactive materials, the focus is on radiologically safe removal and replacement of HEPA filters.

ALARA

The regulations governing workers in the DOE complex contained in 10 CFR 835[1] mandate the documentation of a radiation protection program (RPP) that is approved by DOE. The content of the RPP is to be commensurate with the nature of the activities performed, but must include formal plans and provisions for applying the ALARA process. Giving due consideration to the economics of various activities, this means that all activities involving radiation or radioactive materials must be performed in a manner that maintains exposure to radiation at the lowest possible level. The formal plans for maintaining exposures at ALARA levels should include provisions for and descriptions of the following elements:

- A formal, written, high-level management policy statement invoking management's commitment to the ALARA process
- An ALARA Committee consisting of members of various disciplines that advises management on improving progress toward minimizing radiation dose and radiological releases
- An organization specifically designed to implement the ALARA program
- A formal ALARA training program
- ALARA design reviews of new processes and equipment
- Internal assessments and audits to evaluate the ALARA program
- Pre- and post-job review and analysis
- Individual and collective dose estimation
- In some cases, mock-ups or dry runs

The newer air handling systems have generally incorporated the ALARA philosophy in the initial design, which is the primary means that should be used for minimizing exposures. However, older air handling systems may not have benefited from these concepts. As such, existing ALARA programmatic requirements (e.g., administrative controls, procedures, etc.) must serve to minimize personnel exposure. These requirements are discussed below.

Training Requirements

All individuals must receive training in accordance with the requirements of 10 CFR 835[1] before being allowed unescorted access to controlled areas and before receiving any occupational dose. Specific topics listed in the regulations must be covered in the training program. In addition, various levels of training, commensurate with the positions of the individuals, should be provided in accordance with DOE-STD-1098-99.[4] Radiation workers receive detailed training in understanding the nature and hazards of radiation and understanding their responsibilities for implementing ALARA principles. Personnel most affected include technical support personnel, personnel responsible for developing work plans for working in controlled areas, and personnel responsible for implementing radiological control measures. The training includes the basics of the ALARA concepts and techniques used to minimize their exposures such as shielding, containment devices, the use of special tools, and the importance of careful planning prior to conducting the work.

In addition, on-the-job training is critical for tasks performed in areas where radiation levels can be high. It is important to be familiar with the task and to be prepared with all tools required on the job to minimize the time spent in an area and to eliminate the need for stopping the job and leaving the area to acquire tools. This may also consist of conducting dry runs before attempting any job in a high radiation area. In some air handling systems that use HEPA filters, the filters can have very high radiation levels. Although there are different procedures for changing these filters, personnel must be trained in each procedure as necessary. However, for personnel who may use a bag-in/bag-out system for the first time, conducting a dry run is recommended.

Radiation Surveys

HEPA filters are designed to collect particles down to 0.3 :m with an efficiency of 99.97 percent. The air streams in which the HEPA filters are used can contain highly radioactive particles. As such, the filters become contaminated and can sometimes have significant radiation levels when they are due for replacement. The filter housings and the filters themselves should be surveyed prior to filter removal and replacement, and personnel should be familiar with these radiation levels. The radiation surveys are usually discussed as part of the pre-job review. In most situations, a member from the Health Physics Program must be present to make the radiation surveys. However, in some instances where maintenance personnel or work groups have been trained, surveys can be made by the individuals in the group. Such instances may be site-specific, and self-surveys should be discussed with Health Physics personnel.

Bioassay

Bioassays are part of the internal dosimetry program, which generally consists of the three elements listed below, each is which is designed to either minimize the intake of radioactive materials, evaluate actual or suspected intakes, or calculate the potential doses resulting from these intakes.

- An air monitoring program
- An individual monitoring program, using direct or indirect radiobioassay
- A dose evaluation program to evaluate air sampling and bioassay data to determine the individual doses

Health Physics personnel provide these services and usually determine who will participate in the bioassay program based on regulatory and programmatic requirements.

Radiological workers are required to participate in an internal dosimetry program, including routine bioassays if, under normal conditions, they are likely to receive a committed effective dose equivalent of 1 mSv (100 mrem) or more from all occupational radionuclide intakes in a year [10 CFR 835.402(c)[1]]. For typical HEPA filter removal without the use of bag-out systems and for personnel who rely more on the use of respiratory devices, participation in a routine bioassay program is mandatory.

Posting and Labeling

In some circumstances, it is not possible to use a bag-in/bag-out system for changing the HEPA filters. In these situations, other precautions must be taken. If the filter housing is contained within a room, the door to the room can be posted with the appropriate radiation and/or contamination area sign(s) and access can be restricted. In the event the area around the filter housing is an open area, physical barriers such as ropes and stanchions can be placed so that access into the area is controlled by the barriers or by personnel. Entrance to areas that are barricaded must be posted with appropriate radiation and/or contamination area signs to inform personnel of the potential hazard in the area.

After the HEPA filters are removed from the system, they must be surveyed and labeled with radiation and/or contamination labels that identify their magnitudes. Other materials such as contaminated tools and used protective clothing must be bagged, surveyed, and labeled appropriately before they are removed from the area.

Dosimetry

Personnel who work in controlled areas where they are likely to receive doses at or above those specified in 10 CFR 835.402[1] are required to wear dosimeters for monitoring their effective dose equivalent. Film badges, track-etch dosimeters, thermoluminescent dosimeters, or other radiation-sensitive devices specified by Health Physics personnel could be used to measure the external dose. The dosimeters are used typically to monitor dose to the whole body. In some circumstances, supplemental dosimetry may be required and would be specified on the RWP. The supplemental dosimeters may be used to monitor the extremities if remote handling of the radioactive sources is not feasible or for monitoring the lens of the eyes depending on the specific job and the nature of the radiation fields. The location of the extremity dosimeters will be specified by health physics. Care must be taken to avoid contamination of the dosimeters.

11.2.2 HEALTH PHYSICS WORK REQUIREMENTS

In addition to the requirements mentioned above, there are a number of prerequisites before approval is granted for individuals to perform work in radiological areas. These prerequisites begin with the work group initiating an RWP that contains information about the work to be done and submitting it to health physics. Based on the information provided, Health Physics personnel will make the necessary radiation and contamination surveys and establish a radiological control area around the work site. Health Physics will also establish and specify on the RWP those additional requirements to be followed before, during, and after completion of the work. Some of the information that should be included on the RWP is described below.

Radiological Work Permit

The RWP is an administrative mechanism used to establish controls for the work to be accomplished. The RWP contains information that informs workers of the radiological conditions in an area and prescribes basic requirements for conducting the work in a safe and expeditious manner. The RWP generally includes the following information (DOE-STD-1098-99[4]).

Description of the work

- Radiological conditions in the area
- Dosimetry requirements
- Pre-job briefing requirements
- Training requirements for entry
- Protective clothing and respiratory protection requirements
- Radiological control coverage and stay-time controls, as applicable
- Limiting radiological conditions that may void the RWP
- Special dose or contamination reduction considerations
- Special personnel frisking considerations
- Technical work document number, as applicable
- Unique identifying number
- Issue and expiration dates
- Authorizing signatures

The RWP should be integrated with other work authorizations that address health and safety issues, such as those for industrial safety and hygiene. The RWP also serves the purpose of relating doses received with specific jobs to support the ALARA program.

A typical RWP for the removal and replacement of contaminated or radioactive HEPA filters would specify the applicable items listed above, as well as some special instructions. These special instructions may include ensuring a radiation survey is conducted before each filter is removed or replaced; stopping work if there is a breach in any containment system such as the bag-in/bag-out system or any sleeving material that may be used; ensuring the work crew has participated in a whole body count if respirators are to be worn; specifying the maximum allowable exposure for each individual conducting the work; and/or requiring a post-job briefing. All conditions specified on the RWP must be thoroughly understood and implemented.

Pre-job Review and Briefing

HEPA filter removal and replacement is, in many cases, a relatively simple task. However, it may not be frequently performed, so it should be carefully planned, as should all work in radiological areas. A pre-job review and briefing should be conducted to ensure all personnel are familiar with the task and the radiological requirements that may be imposed. The briefing should include the following items.

- A review of the RWP to ensure all conditions and requirements are understood and met
- A review of the instructions regarding hold points
- A review of the radiation survey that normally accompanies the RWP, taking particular note of the areas of highest and lowest radiation levels
- The scope of the work to be conducted (i.e., how many filters will be replaced, what technique will be used, what location is the system in, etc.)
- Information concerning whether the area around the system is to be barricaded and step-off pads will be used, or if a bag-in bag-out system is to be used
- Coordination with operations personnel to ensure the system to be worked on is not needed and is tagged out
- Established conditions for stopping work, e.g., unexpected radiation levels, contamination due to system breach, dropped filter, etc.
- Established plans for cleanup and restoring the area
- Identification of the tools and equipment needed and ensurance of their availability
- Scheduling of the work at a convenient time to avoid delays in the work process (i.e., not near break time or lunch)

- Ensuring that preparation for disposal of filters is coordinated with the waste management group
- Minimizing the material to be taken into the area to limit waste generation
- Reviewing the individual and collective doses estimated for the job
- Establishing the number of personnel required for the job

This review should be conducted with all of those personnel who will be involved in the job and with those operations personnel who have control over the system where the work will take place.

Hold Points

Hold points may be predetermined for operational reasons or may result from unusual conditions that occur during performance of the task. Predetermined hold points should be specified in the procedure/technical work document or on the RWP (as indicated above). These hold points would exist in situations such as a breach in any control system or an increase in radiation on the HEPA filter beyond expected levels (based on the original survey). Obvious stop work conditions would exist if personnel felt discomfort due to use of respiratory equipment, heat stress, or fatigue for any reason.

Air monitoring

Air monitoring is required by 10 CFR 835.403(a)(2)[1] to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed. The use of containment devices is often not amenable for removal and replacement of some HEPA filters. In such situations, respiratory protection equipment could be prescribed and air monitoring would then be required. Care must be taken to locate the air monitoring equipment to ensure the sample represents the concentrations of airborne radioactive material that workers would breathe if respirators were not worn. The potential intake of radioactive material can be determined using these measured concentrations and the protection factor for the particular respirator used. Health Physics personnel would designate the type of monitoring and the location of the monitors. They also would collect the data from the air monitoring devices and make any calculations, if required.

11.2.3 Technical Work Document

The technical work document/procedure provides guidance to the personnel who will perform the task. A procedure is required for removal and replacement of HEPA filters. This procedure must be written for the specific method to be used and must include step-by-step instructions. Typical procedures for removal of HEPA filters with and without a bag-out system are described briefly below.

Use of a Bag-Out-System

A bag-out system is a good example of implementation of the ALARA process. It minimizes the possibility of creating an airborne radioactivity area, eliminates the need for respiratory equipment, and minimizes the need for follow-up bioassays on the work crew. This system should be used whenever possible, as recommended in a Lessons Learned Communication[14] reported by Brookhaven National Laboratory describing the use of a glovebag system to remove a large HEPA filter.

Since HEPA filters may vary in size, preparation should include ensuring the availability of the appropriate size of bag-out system before entering the work area. The fasteners holding the filter door shut should be loosened to minimize the use of tools once the bag-out system is in place. All of the tools that will be used should be placed in the bag-out system, recognizing that the tools may become contaminated. The glove bag should then be sealed around the filter housing. Using the glove ports, the filter housing door should be opened and the filter moved to the edge of the housing where another individual can assist in its removal if the filter is too large for one person to handle. The filter should then be moved to the farthest end of the plastic sleeve, which should then be sealed with tape a foot or two from the filter. The tape should be wrapped a sufficient distance over the plastic sleeve to permit cutting it in the center of the tape seal to ensure no contamination is released. If a new filter is to be installed, the plastic sleeve should be cut from the inside to allow insertion of a new filter. After installation of the new filter, the doors should be shut and securely fastened, and the glove bag should be carefully removed and sealed. Health Physics personnel should survey all tools, the filter housing, and the removed filters, and label them accordingly.

Filter Removal without a Bag-Out System

If use of a bag-out system is not possible, the steps taken for opening the housing and removing and replacing the HEPA filter would be essentially the same as described above. The used filter would require careful handling to avoid spreading contamination and would have to be wrapped in some suitable material such as plastic. However, additional health physics measures would be required, including barricading the area around the filter housing, ensuring the area is posted to warn personnel of the radiological conditions, performing air monitoring, placing a step-off pad at the entrance to the area, and providing a frisker for personnel to survey themselves for contamination after completion of the job. All personnel should wear full protective clothing, including respirators, and frisk themselves for contamination before leaving the area. The personnel would also be required to submit to a whole body count or bioassay.

11.2.4 POST-JOB REQUIREMENTS

To obtain some lessons learned, provide additional training, and assist in supporting the ALARA program, a post-job review should be held. This review should focus on the manner in which the work was conducted to provide an opportunity for personnel to learn from their success or failure, as the case may be, in performing the work. Such post-job reviews and discussions also aid in ensuring the safety of the personnel who will perform the task in the future, and are normally conducted in an expeditious manner.

Whole Body Counts

Whole body counts are not normally provided for all radiological workers unless they are required to wear respirators. However, depending on the procedure used for removal and replacement of the HEPA filters (e.g., whether respirators were worn), whole body counts or bioassays may be required upon completion of the job. In addition, whole body counts would be required if there were an unexpected release of airborne radioactive materials, if contamination were detected on an individual's face, or if there were a failure in the protective clothing or control devices. Whole body counts are not suitable for detection of all radionuclides and are only one part of the bioassay program for the detection of internal contamination. Health Physics personnel should be consulted to ensure the appropriate method is used for evaluation of any potential internal contamination.

Contamination Surveys

Contamination control is an important and necessary part of any Health Physics program. Contamination should be limited through engineering controls and proper work practices. However, it is not always possible to prevent contaminating surfaces when opening contaminated systems or working on contaminated equipment (e.g., changing HEPA filters). Since contamination is easily transferred from one area to another via either air movement or transport on shoes or protective clothing, it is necessary to establish controls at the work area. To ensure contamination is not spread outside of the work area, Health Physics personnel should establish a contamination control zone. A rope barrier usually designates this control zone along with appropriate postings specifying the levels of contamination and/or radiation in the area. Entrance to these areas should require the individual to wear appropriate protective clothing (sometimes multiple layers depending on the levels of contamination). A step-off pad is usually placed at the entrance and exit from the contamination areas where personnel remove their contaminated clothing prior to leaving the area. Upon completion of the task in the contamination zone, the following steps must be taken to restrict the contamination from being spread by personnel and equipment.

- Personnel Surveys – Personnel exiting the contamination area may be required to remove their protective clothing at the control point. Personnel must frisk themselves with a radiation-monitoring device that is maintained at the step-off pad. Existing procedures should be followed to ensure personnel use the proper techniques for removing protective clothing and performing a whole body frisk if portable monitoring devices are used. Care must be taken to ensure the frisking is performed in a slow, methodical manner to ensure the detection capability of the instrument is not compromised. Personnel should also frisk any personal items brought into the area such as pencils, papers, jewelry, badges, etc.

- Equipment Surveys – A trained individual, normally from the Health Physics program, must monitor the equipment leaving the work area. However, for HEPA filter removal and replacement, it is unlikely that equipment other than the hand tools necessary to change the filter will be brought into the area. Some of these tools may be designated radiological tools because they have fixed contamination and may be maintained separately from uncontaminated tools. Health Physics personnel should determine whether the tools have been contaminated with removable contamination by performing smear surveys. The HEPA filter itself must be enclosed in some containment device such as plastic, treated as radioactive, surveyed for contamination and radiation, and appropriately labeled. It should then be held or transported for disposition possible incineration, or direct disposal as radioactive waste.
- Area Surveys – Upon completion of the task, i.e., removal of the HEPA filter(s) and securing the system housing, the area must be surveyed for radiation and contamination. If contamination is found, the area must be decontaminated and resurveyed until removable contamination no longer exists. A radiation survey must be performed in the area to ensure that the conditions that existed prior to the work did not change and the area is appropriately posted as necessary.

Waste disposal

The final step upon completion of the work is to perform housekeeping in the area while the area is being cleared for general use by health physics. Some of these housekeeping chores involve gathering all the protective clothing for transport to the laundry or shipping to an offsite laundry service and ensuring that all waste materials are packaged and labeled appropriately for disposition as waste. These materials include the step-off pads, the containers in which the used HEPA filters are placed, and any miscellaneous materials used in performing the work.

11.3 Occupational Safety

11.3.1 Electrical Safety

Electrical potentials in excess of 200 volts are common around ventilation systems. Therefore, employees performing filter testing must be aware of electrical hazards. OSHA regulations and prudent practice limit electrical work to qualified personnel. Only a qualified person may perform any repair, installation, or testing of electrical equipment. Workers need to be aware of exposed energized parts in the vicinity of the work. Electrical circuits must be considered energized until opened and locked out according to established procedures and must be tested to verify that the circuit is de-energized. If it is necessary to de-energize electrical circuits to conduct work, the circuits must be de-energized and locked out by qualified personnel. A significant factor in preventing electrical accidents is awareness of possible electrical hazards. Workers should point out hazards to qualified persons. A good housekeeping program can significantly reduce electrical hazards.

Personnel should examine electrically powered equipment and tools for problems. Personnel must not use equipment with frayed or damaged cords or with missing ground pins from the plug (including extension cords). If testing equipment is custom-built, has not been tested by a nationally recognized testing laboratory, or has been modified, the workers should consult qualified electrical safety personnel before using the equipment. Workers should not assume that low voltage controller circuits are free of hazards. Even relatively low voltage may cause injury or startle the worker and cause a fall. Some controller circuits contain higher voltages.

11.3.2 Machine Guarding

Ventilation systems contain rotating shafts, moving belts, gears and other moving equipment that may present hazards to workers. Such hazards have produced serious injuries and even